which, after manipulation, yields the geometric sum formula.

Solution to Exercise 5.6.3

If the sampling frequency exceeds the Nyquist frequency, the spectrum of the samples equals the analog spectrum, but over the normalized analog frequency fT . Thus, the energy in the sampled signal equals the original signal's energy multiplied by T.

Solution to Exercise 5.7.1

This situation amounts to aliasing in the time-domain.

Solution to Exercise 5.8.1

When the signal is real-valued, we may only need half the spectral values, but the complexity remains unchanged. If the data are complex-valued, which demands retaining all frequency values, the complexity is again the same. When only K frequencies are needed, the complexity is $O(KN)$.

Solution to Exercise 5.9.1

If a DFT required 1ms to compute, and signal having ten times the duration would require 100ms to compute. Using the FFT, a 1ms computing time would increase by a factor of about $10\log_2 10 = 33$, a factor of 3 less than the DFT would have needed.

Solution to Exercise 5.9.2

The upper panel has not used the FFT algorithm to compute the length-4 DFTs while the lower one has. The ordering is determined by the algorithm.

Solution to Exercise 5.9.3

The transform can have **any** greater than or equal to the actual duration of the signal. We simply "pad" the signal with zero-valued samples until a computationally advantageous signal length results. Recall that the FFT is an **algorithm** to compute the DFT (Section 5.7). Extending the length of the signal this way merely means we are sampling the frequency axis more fnely than required. To use the Cooley-Tukey algorithm, the length of the resulting zero-padded signal can be 512, 1024, etc. samples long.

Solution to Exercise 5.10.1

Number of samples equals $1.2 \times 11025 = 13230$. The datarate is $11025 \times 16 = 176.4$ kbps. The storage required would be 26460 bytes.

Solution to Exercise 5.10.2

The oscillations are due to the boxcar window's Fourier transform, which equals the sinc function.

Solution to Exercise 5.10.3

These numbers are powers-of-two, and the FFT algorithm can be exploited with these lengths. To compute a longer transform than the input signal's duration, we simply zero-pad the signal.